The Relationship Between Density and Concentration – A Mathematical Model

Introduction:
The density of a sample of matter represents the mass contained within a unit volume of space in the sample. For most samples, a unit volume means 1.0 mL. The units of density, therefore, are quoted in terms of grams per milliliter (g/mL) or grams per cubic centimeter (g/cm^3) for most solid and liquid samples of matter. Densities are usually determined and reported at 20°C (around room temperature) because the volume of a sample, and hence the density, will often vary with temperature. This is especially true for gases, with smaller (but still often significant) changes for liquids and solids.

Density can also be used to determine the concentration of solutions in certain instances. When a solute is dissolved in a solvent, the density of the solution will be different from that of the pure solvent itself. Handbooks list detailed information about the densities of solutions as a function of their composition (typically, in terms of percent solute in the solution). If a sample is known to contain only a single solute, the density of the solution could be measured experimentally, and then the handbook cold be consulted to determine what concentration of the solute gives rise to the measured solution density.

For liquids, very precise values of density may be determined by pipeting an exact volume of liquid into sealable weighing bottle (this is especially useful for highly volatile liquids) and then determining the mass of liquid that was pipeted. A more convenient method for routine density determinations for liquids is to weigh a particular volume of liquid as contained in a graduated cylinder. It is this second technique that will be used in this lab.

The concentration of solutions is often expressed in terms of the solution's *percentage composition* on a weight basis. For example, a 5% sodium chloride solution contains 5 g of sodium chloride in every 100 grams of solution (which corresponds to 5 g of NaCl in every 95 g of water present).

Materials:
10.00 mL Graduated cylinder
Analytical balance
NaCl solutions: 5%, 10%, 15%, 20%, 25%, 2 unknowns
Transfer pipets

Procedure:
A) Determination of the density of solutions of known and unknown concentration
   1) Your instructor has prepared NaCl solutions of the following percentages by weight: 5%, 10%, 15%, 20%, and 25%. Make a mass determination for 10.00 mL of each solution.Be certain to record the temperature for each solution.
   2) Make a mass determination for 10.00 mL of each of the two unknown solutions, again recording the temperature for each solution.

Suggested Data Table

	Solutions						
	5%	10%	15%	20%	25%	Unknown #1	Unknown #2
Temperature (°C)							
Mass (g)							
Volume (mL)							
Density (g/mL)							

B) Determining the Concentration of the Unknowns
   1) Determine the concentrations of the unknowns using a graph
   2) Determine the concentrations of the unknowns using Linear Regression. Be sure to report the equation for your line, as well as values for r and r^2. Be certain to address (in your abstract) any deviation from the expected value for the y-intercept.